DECISION RISK ANALYSIS OF THE RUN-FLAT FOLDING SIDEWALL TIRE

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1. INTRODUCTION & DESCRIPTION:

The purpose of the study was to raise the main issues and risks associated with the "Run-Flat Folding Sidewall" Tire.

The basic principle for the Folding Sidewall Tire was independently developed by the B. F. Goodrich Company and has been funded by the U. S. Army Tank-Automotive Command (TACOM) since July 1967. Development has been tried on various size tires, but to date only the 7.00 X 16 size has been successfully accomplished.

When loss of inflation occurs, the tire is fabricated to allow the sidewall to fold inward providing a triple layer for support. The characteristics and cost of both the current and development tire are shown in Table 1. All other characteristics, including ply rating, tread depth, wheel size and diameter are basically equal.

TABLE 1

CHARACTERISTICS

	STD	RUN FLAT
Type	Tube	Tubeless
Weight (lbs.)	27	41
Run-Flat Dia. (in.)	N/A	24.25
Production Cost (dollars)	14.69	49.00 (Contractor Estimate) (for up to 5000 Tires)

2. DISCUSSION:

Two major tests have been performed on the 7.00 X 16 Folding Sidewall Tire. One test of 15,000 miles was conducted by B. F. Goodrich in October 1968 and the second was run for 3,150 miles at the Yuma Proving Grounds. The reports did not provide an evaluation of vehicle component wear rates with respect to operating in a run flat condition or sufficient data to evaluate mobility or tread wear in varied geographical areas.

B. F. Goodrich tested the tires on a M151A1 operating 70% of the time on highway and 30% on gravel roads. Although the standard tire operates for 8000 miles in the field, based on the B. F. Goodrich test, they estimated the life of the Folding Sidewall Tires at 34,700 miles while the standard tire was estimated to last 17,400 miles. Vehicle handling was stated to be good, allowing near normal operation even with flat tires. The total test included operation for 300 miles with individual front tires flat and 175 miles with rear tires flat.

Yuma Proving Grounds tests identified a potential life of 12,000 miles for the Folding Sidewall Tire. Vehicle handling was basically identical for both types of tires, but some pulling was noted when a single tire was deflated. The test included 50 miles of operation of each tire in the deflated mode. Sand mobility tests were also conducted at Yuma. These showed that under normal pressures the tire showed increased mobility due to the spread of the tire.

Speed tests were run at Quantico, Virginia with the tires in both inflated and deflated modes. Speed varied from 23 MPH inflated to 16 MPH deflated.

One hundred tires were furnished to the Marine Corps for a six month troop test in early 1972. No reports have been received covering that operation. In addition, forty-two tires were furnished to the Vietnam Laboratory Assistance Program for a four month troop test which was not conducted due to the phase-down.

Additional testing would be required to determine items shown in Table 2 while major problems and questions related to logistics and procurement are shown in Table 3.

TABLE 2

ADDITIONAL TEST REQUIREMENTS

(1) Performance under Arctic conditions.

(2) Performance of tubeless Folding Sidewall tires on rims dented by cross-country operation.

(3) Tire chain effect.

(4) Retreaded tire operation (retreading accomplished but not tested.

(5) Cross-country operation in deflated mode with a loss of 3-1/8" ground clearance.

(6) Effects of deterioration or "memory" loss of the pre-stressed side wall during storage.

TABLE 3

(1) Mounting of the Folding Sidewall Tire can only be accomplished with a special Mounter-Demounter. The prototype unit costs $750 with no production estimate available.

(2) Proprietary rights for the tire belong to the B. F. Goodrich Company, therefore restricting the Government to a sole source procurement.

(3) Should the Folding Sidewall Tire be used for general or special purpose application?

(4) Could spare tires be eliminated on vehicles using Folding Sidewall Tires, and if so, what echelons would stock, transport, and repair?

(5) If the prime mover used Folding Sidewall Tires, what tires would the trailer mount and would spares have to be added to the trailer?

3. COST EFFECTIVENESS:

In a direct comparison of the tire systems, incorporation of a tube for the standard tire and the proportionate share of the Mounter-Demounter to the Folding Sidewall Tire establishes a tentative comparison cost of $17.05 versus $50.00 (Table 4).

TABLE 4

COSTS

	STD	RUN FLAT
Tire Procurement	$14.69	$49.00
Tube	$ 2.36	-
Mounter-Demounter		$ 1.00
	$17.05	$50.00

Using the estimated mileages given in both the Goodrich and Yuma Test Reports, cost per mile as an index of Cost Effectiveness is shown in Table 5.

TABLE 5

	B. F. GOODRICH TEST REPORT		YUMA TEST REPORT	
	STD	RUN FLAT	STD	RUN FLAT
Est. Tread Life (Mi)	17400	34700	8000	12000
Total Cost (dollars)	17.05	50.00	17.05	50.00
Cost Per Mile (cents)	.098	.144	.213	.417

Since the data in Table 5 only reviews potential tire mileage and ignores all other aspects of safety and combat effectiveness, two versions of utilization were reviewed - General Purpose and Special Purpose Application. In the actual study, both foam-filled and "combat" tires (12 ply sidewall) were considered but high procurement costs resulted in their being dropped from consideration.

In the General Purpose Application, the assumptions shown in Table 6-8 were made.

TABLE 6

PROBABILITY ASSUMPTIONS

GENERAL APPLICATION

- Probability of conflict - 75-85 - 50%
- Probability of specific truck in combat - 50%
- Probability of being exposed to hostile fire - 40%
- Probability of combat loss due to tires - 2%

.50 X .50 X .40 X .02 = .002

TABLE 7

TIRE ASSUMPTIONS

	STD	RUN FLAT
Average Life (Miles)	8000	12000
Tires Per Set	5	4
Mileage Per Set	10000	12000
Tires Per 60000 Miles	30	20
Cost	$511.50	$1000.00

TABLE 8

COMBAT LOSS ASSUMPTIONS

- Given that a combat loss occurs solely due to a flat tire completely incapacitating the vehicle, a cost penalty of $50,000 is assessed against the standard tire to represent personnel and material cost.

- Given that a tire is punctured during combat operations, a cost penalty of $2000 is assessed against the Folding Sidewall Tire to represent some loss in mobility.

The decision matrix for the General Purpose Application is shown in Table 9 and shows a total preference for the standard tire.

TABLE 9

DECISION MATRIX

TIRE	SYSTEM COST	COMBAT LOSS	NO LOSS .998	LOSS .002	TOTAL
Standard	$ 511.50	$50000.00	$510.48	$101.62	$ 611.50
Run Flat	$1000.00	$ 2000.00	$998.00	$ 6.00	$1004.00

For the Special Purpose Application, 1/4 ton vehicles mounting the 106 Recoiless Rifle were considered. The probabilities were changed to reflect a 90% probability of being assigned to a Combat Area and 90% probability of exposure to enemy fire. With these changes, the probability of loss due to tires changed to .008. With these changes, the decision matrix is as shown in Table 10 with again the standard tires showing a slight edge from a cost-effective standpoint.

TABLE 10

DECISION MATRIX

TIRE	SYSTEM COST	COMBAT LOSS	NO LOSS .992	LOSS .008	TOTAL
Standard	$ 511.50	$50000.00	$507.41	$404.09	$ 911.50
Run Flat	$1000.00	$ 2000.00	$992.00	$ 24.00	$1016.00

4. SENSITIVITY ANALYSIS:

Because the difference between tires in the Special Purpose Application was about ten percent, it was determined that a sensitivity analysis should be conducted on each of the parameters including tire mileage, unit cost, and combat loss probability. Each of these parameters were reviewed individually and combined one step variation was performed for the Folding Sidewall Tire. The individual parameters sensitivity analyses are shown in Tables 11-13. It can be readily seen that the standard tire consistantly reflects a lower total cost regardless of the sensitivity tested, except where the run-flat total cost is less than $44.78.

TABLE 11

EXPECTED TIRE COST - 60000 MILES

MILEAGE	RUN FLAT	STD
6000	$2,016.00	$1,082.00
6642	$1,882.00	$1,016.00
8000	$1,516.00	$ 911.50
10000	$1,216.00	$ 809.20
12000	$1,016.00	$ 741.00
13393	$ 911.50	$ 706.90
14000	$ 871.00	$ 691.56
16000	$ 766.00	$ 655.75

TABLE 12

UNIT COST SENSITIVITY

EXPECTED TIRE COST - 60000 MILES

RUN FLAT	STD ($17.50)	RUN FLAT
$38.00		$ 776.00
$41.00		$ 836.00
$44.78		$ 911.50
$47.00		$ 956.00
$50.00	$911.50	$1,016.00
$53.00		$1,076.00
$56.00		$1,136.00

TABLE 13

COMBAT LOSS PROBABILITY SENSITIVITY

NO LOSS	COMBAT LOSS	EXPECED TIRE COST - 60000 MILES STD	RUN FLAT
.996	.004	$ 711.50	$1,008.00
.995	.005	$ 761.50	$1,010.00
.994	.006	$ 811.50	$1,012.00
.993	.007	$ 861.50	$1,014.00
.992	.008	$ 911.50	$1,016.00
.991	.009	$ 961.50	$1,018.00
.990	.010	$1,011.50	$1,020.00
.989	.011	$1,061.50	$1,022.00
.988	.012	$1;111.50	$1,024.00

Combat loss sensitivity is a direct relationship of $8.00 for each $1000 increment of cost applied. Therefore, the allowable combat loss cost for the standand tire could increase to $63,000 before the Folding Sidewall Tire cost could result in an equal increase in the standard tire cost.

Since the unit cost and mileage for the standard tire are relatively firm based on historical data, a one step matrix in favor of the Folding Sidewall Tire was accomplished and is shown in Table 14. The average mileage was increased to 14,000 miles and the unit cost was reduced to $47.

TABLE 14

DECISION MATRIX - SENSITIVITY

TIRE	SYSTEM COST	COMBAT LOSS	NO LOSS .991	COMBAT LOSS .009	TOTAL
Std	$511.50	$50000	$506.90	$454.60	$961.50
Run Flat	$803.70	$ 2000	$796.47	$ 25.23	$821.70

5. CONCLUSIONS:

In the final evaluation, it was found that the standard tire was always more cost effective. If we held the standard tire mileage and unit cost at their current established figures of 8000 miles and $17.05, by varying the values for the Folding Sidewall Tire it can be made more cost effective. Variations in the conditions shown in Table 15 will reverse the original decision.

TABLE 15

VARIATION IN DATA

• Probability of Combat Loss	.010
• Average Combat Loss Cost - Standard Tire (with Folding Sidewall held at $2000)	$63,000
• Average Mileage - Folding Sidewall Tire	13,400
• Unit Cost - Folding Sidewall Tire	$ 44.78

If further testing and a more definitive unit production cost should revise the current data to show that the Folding Sidewall Tire is more cost effective, logistics costs associated with introduction of the new items into the supply system and revised shipping and storage costs should be reviewed prior to final acceptance.